Performance benchmarks for SciGlass ECal

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State of common benchmarks framework

ePIC had inherited benchmarks from Athena:

» `https://eicweb.phy.anl.gov/EIC/benchmarks/detector_benchmarks`

» `https://eicweb.phy.anl.gov/EIC/benchmarks/physics_benchmarks`

» `https://eicweb.phy.anl.gov/EIC/benchmarks/reconstruction_benchmarks`

Something to learn from!

» Running on the grid after each software change (Continious Integration)

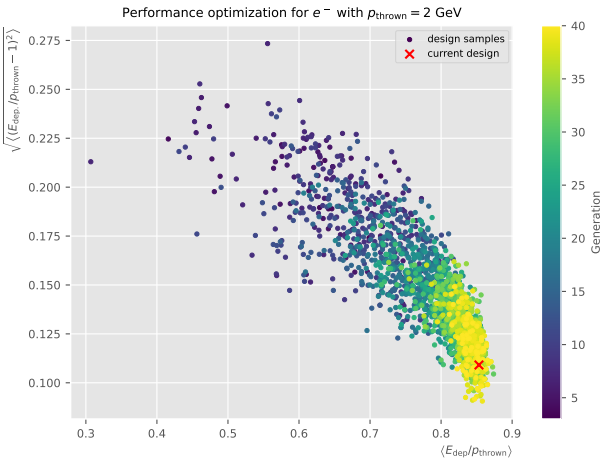
» Transparent procedures – source code available

» Unfortunately, analysis and interface are unsophisticated

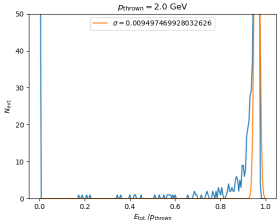
» Not friendly to deadline-driven development - no user adoption

A use case: detector optimization

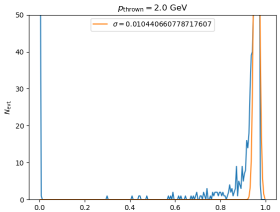
Example toy optimization for 2 objectives:



current design:

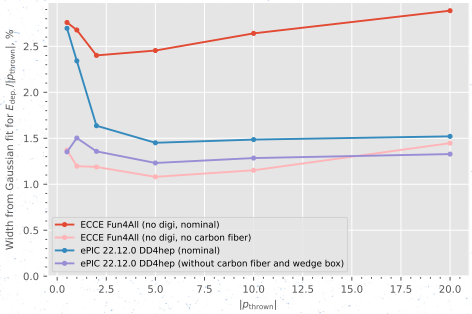


a design with “optimal” resolution:



Real improvement depends on having rigorous and robust benchmarks

Energy resolutions from a Fun4All reproduced in DD4hep



- Disabled SiPM statistics and removed 1 *mm* carbon fiber around towers in Fun4All
- Removed a 0.25 *mm* thin carbon fiber wrap and wedge walls in DD4hep
- Consistent gausian peak widths for electrons

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π rejection for SciGlass in ECCE calorimeter

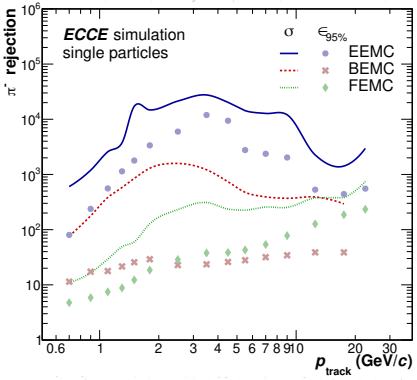
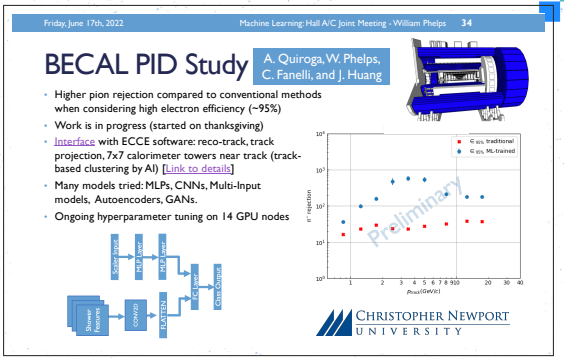


Figure 20: Pion rejection factor for the different ECals with $E/p > 1 - 1.6\,\sigma_e/E$ or based on a $\varepsilon_e \approx 95\%$ cut.

arXiv:2207.09437v1



https://indico.jlab.org/event/546/contributions/9980/attachments/7933/11151/machine_learning_hall_ac_2022_phelps.pdf
(was shown at 2nd EIC AI/ML Workshop)

Rejection at $\epsilon = 95\%$ is given in red points

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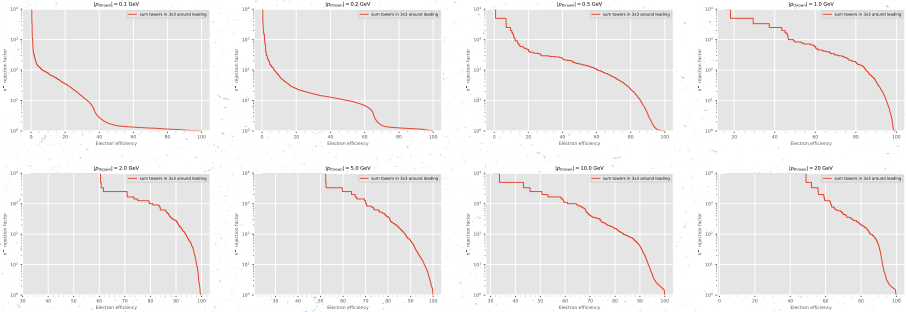
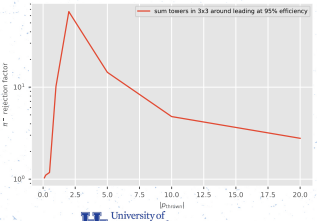
State of the pion rejection study





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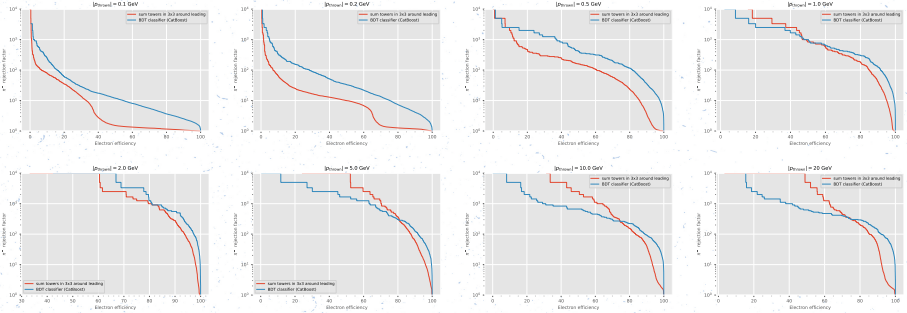
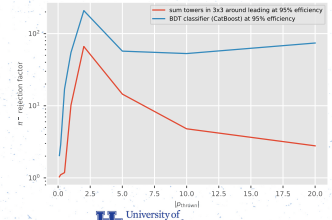
State of the pion rejection study





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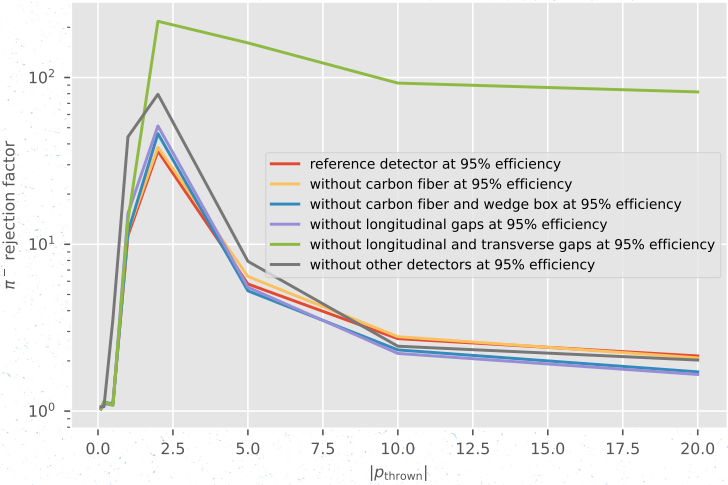
Future steps

- Implement clustering for Sci-Glass
- Implement remaining benchmarks according to the charge
- Study Geant4 material simulation: X_0, λ_{int}
- Implement realistic readout in EICrecon
  - Optical statistics (contribution to the $1/E$ term)
- Porting Imaging/Sciglass analyses to the benchmarks infrastructure?

Backup

- Switch from ePIC geometry version from 22.11.1 to 22.12.0
- Enabled Birks effect correction (relevant for π rejection)

Pion rejection: breakdown



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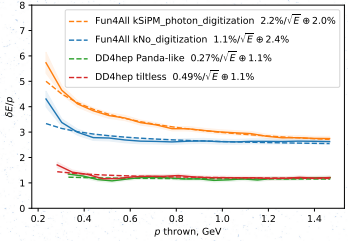
Resolution from the simulations



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6 / 7

https://indico.bnl.gov/event/17074/contributions/68207/attachments/43231/72716/dd4hep_fun4all_cmp.pdf

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ECCE proposal

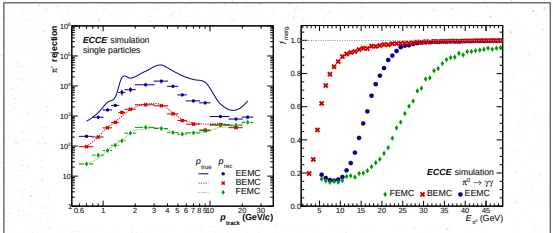

Figure 2.20: (left) Pion rejection factor for the different ECals with $E/p > 1 - 1.6\sigma_E/E$ and shower shape cuts applied as a function of true and reconstructed momentum. (right) Fraction of neutral pions for which the showers from their decay photons are merged into a single cluster and can not be reconstructed using an invariant-mass-based approach for the different electromagnetic calorimeters.

https://doi.org/10.5281/zenodo.6537588

For a Gaussian peak $(1 + \mathrm{erf}(1.6/\sqrt{2}))/2 = 94.5\%$ efficiency - that's not how they've defined, it's more like $(1 + \mathrm{erf}(0.6/\sqrt{2}))/2 = 72.5\%$

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2

https://indico.bnl.gov/event/17706/contributions/70849/attachments/44499/75685/SHA256E-s5115227--974190a22dcbaa41b8860f33dc2db97d7f6d5980359db3a641c6b13994f6e4pdf

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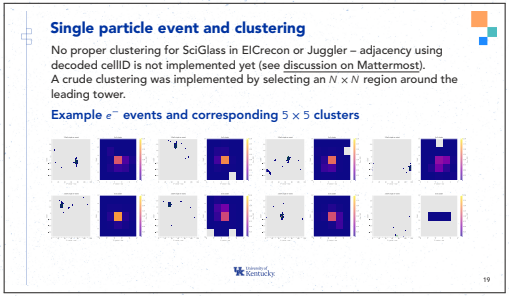
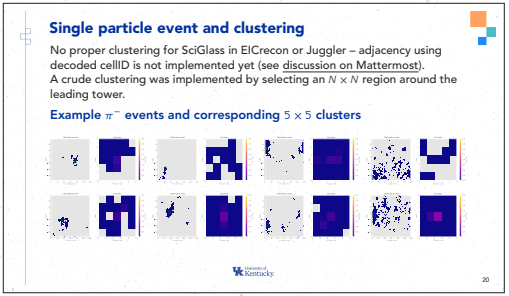
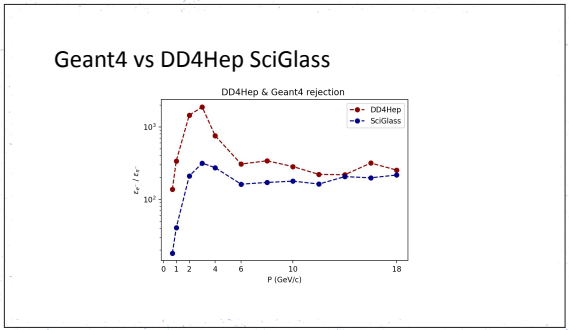




https://indico.bnl.gov/event/17844/contributions/71396/attachments/44966/75855/pi_rejection.pdf

A beam-test simulation wasn't reproduced in DD4hep



https://indico.bnl.gov/event/17710/

- Simulation for 21x21 grid array
- A private Geant4 framework that is also used for beam-test simulation
- DD4hep simulation setup with EcalNegative geometry for SciGlass
- Here, a slightly different definition of the rejection factor is used: (TPR)/(FPR) (instead of 1/(FPR)

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